ORIGINAL ARTICLE

THE ENHANCEMENT OF DRIVER SEAT COMFORT FOR SMALL SIZE CAR: A PRELIMINARY STUDY

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ABSTRACT

Seating comfort is one of the important indicators while driving especially for a long hour drive. The objective of this study was to execute a preliminary study of survey and identify the discomfort of body while driving and after driving session by conducting a survey. The questionnaire developed was tested for its reliability. By using Cronbach's Alpha, this paper's contribution was found to be significant in which it provides a survey with acceptable test reliability in which the alpha (α) was 0.887. The survey was conducted on 30 students of University Malaysia Pahang (20 male and 10 female) with driving experience and valid driving license. The subjects should have experiences in driving small size car or mini car as well. The results showed that the body area that the drivers felt discomfort while driving and after driving should be known. The findings showed that the discomfort was intense at the neck, upper back, and lumbar while and after driving.

Keywords: *Automotive seating, comfort, discomfort, and automotive seating questionnaire*

INTRODUCTION

Comfortable seating is not a luxury but one of the key requirements to mitigate the discomfort felt by the driver. In fact, in recent years, automotive seat manufacturers are competing among them to develop the seat that alleviate discomfort as a respond to consumers' demands[1]. However, comfort is something subjective and difficult to measure, define, and interpret due to its psychophysical nature[2,3]. Therefore, to determine the seating comfort, the information can be collected through human evaluation[4].Measuring the grad of comfort is very challenging since human perception changes with time. Hence, an updated information from the new subjective evaluation is necessary[5].

Many approaches have been utilized in an attempt to measure comfort. To evaluate the comfort of automotive seating, a study usually focuses on the sitting posture analysis, pressure distribution, performance analysis and electromyography[6,7]. However, subjective survey has been commonly used as it is quite reliable and it does not require special measurement instrument[3]. So far, there is no ideal standard of subjective evaluation tools for vehicle seats in the automotive industry but because of its importance, a well-documented evaluation through the development of subjective evaluation tools is crucial[1,2]. The subjective survey requires the experimenter to be professional and it is hard to quantify the results obtained[3].

According to Deros, Daruis, and Nor[4], there are few efforts in establishing and documenting the automotive comfort and discomfort survey. A survey is also required to update the prediction models and guidelines as new measuring techniques are developed[5]. The analysis of previous research states that there are three external factors that contribute to the significant seating discomfort which are seating vibration, hand reach and vibration[8-10].

These days, researchers have been studying the comfort and discomfort of the automotive seat especially for a long hour drive[11]. The study stated that prolonged seating significantly increases the risk of lumbago (low back pain) especially when it is associated with the vibration in body parts. However, the experiences of the drivers are rarely considered.

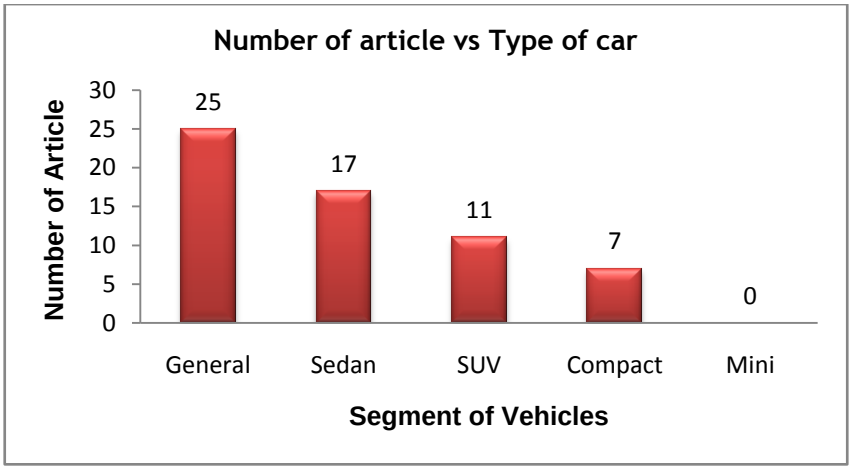


Figure 1- Discomfort study distribution according to the segment of vehicles from 1991-2015

Figure 1 illustrates the number of articles that studied the comfort of car seat. From the total of 60 papers published, none of them has investigated the segment of mini cars. Thus, it is necessary to investigate the discomfort of drivers which focuses on mini car drivers.

The size of a mini car with a dimension of 3400 millimetres in length, 1480 millimetres in width, and 2000 millimetres in height, is very small compared to compact and standard sizecars (see Figure 2). The space from the centre of the seat to the outer door of the vehicle is 442.5 millimetres; create a smaller space than standard size car (see Figure 3). Thus, this is also one of the factors that influence the comfort of a mini car. In many cases of study concerning the comfort of automotive seat, majority considered sedan car rather than compact car or mini size car.

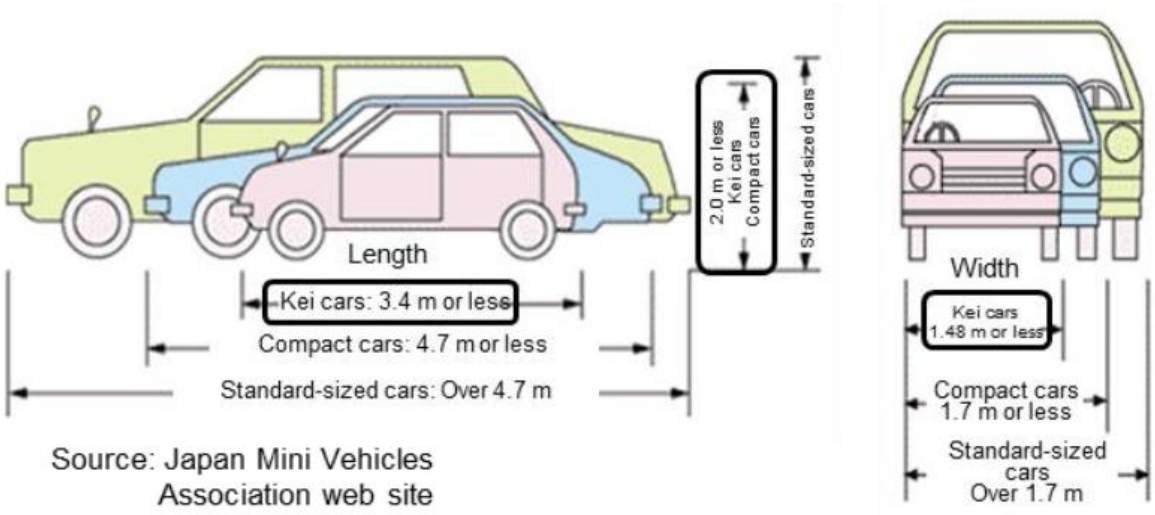


Figure 2- Specification of standard, compact, and mini size cars on the basis of Japan International Standard (JIS)[12]

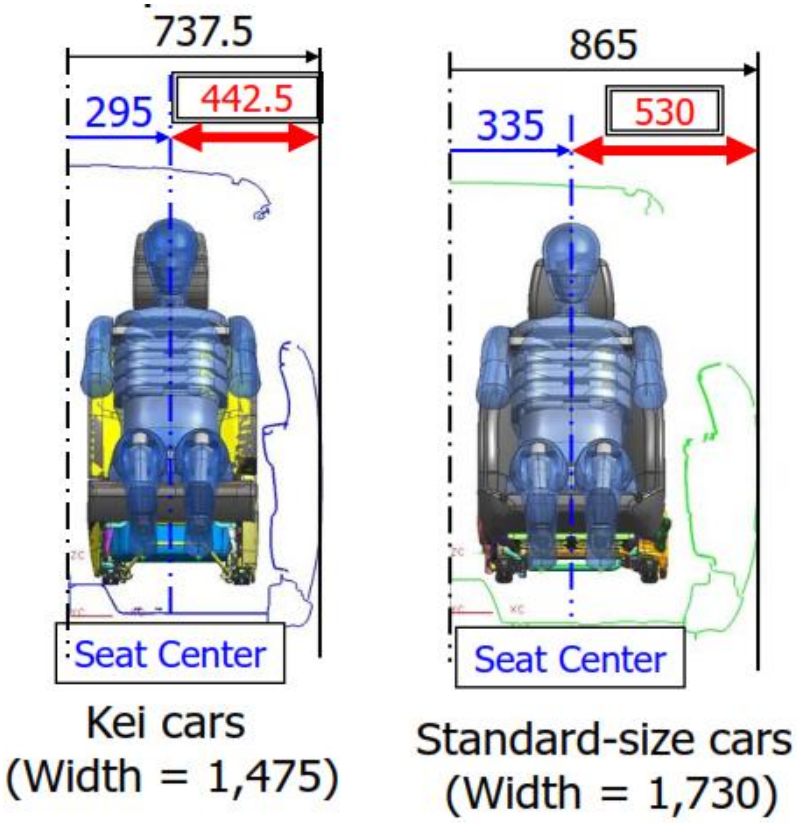


Figure 3- The difference in space between mini size car and standard-size car [12]
(All units are in millimetres)

The objective of this paper is to execute a preliminary study of survey and identify the discomfort of body while driving and after driving session by conducting the survey. To do the survey, the questionnaire developed is tested for its reliability using Cronbach's Alpha. The developed questionnaire aims to analyze the seating comfort during and after a long hour drive, which is currently lacking in the automotive seating industry.

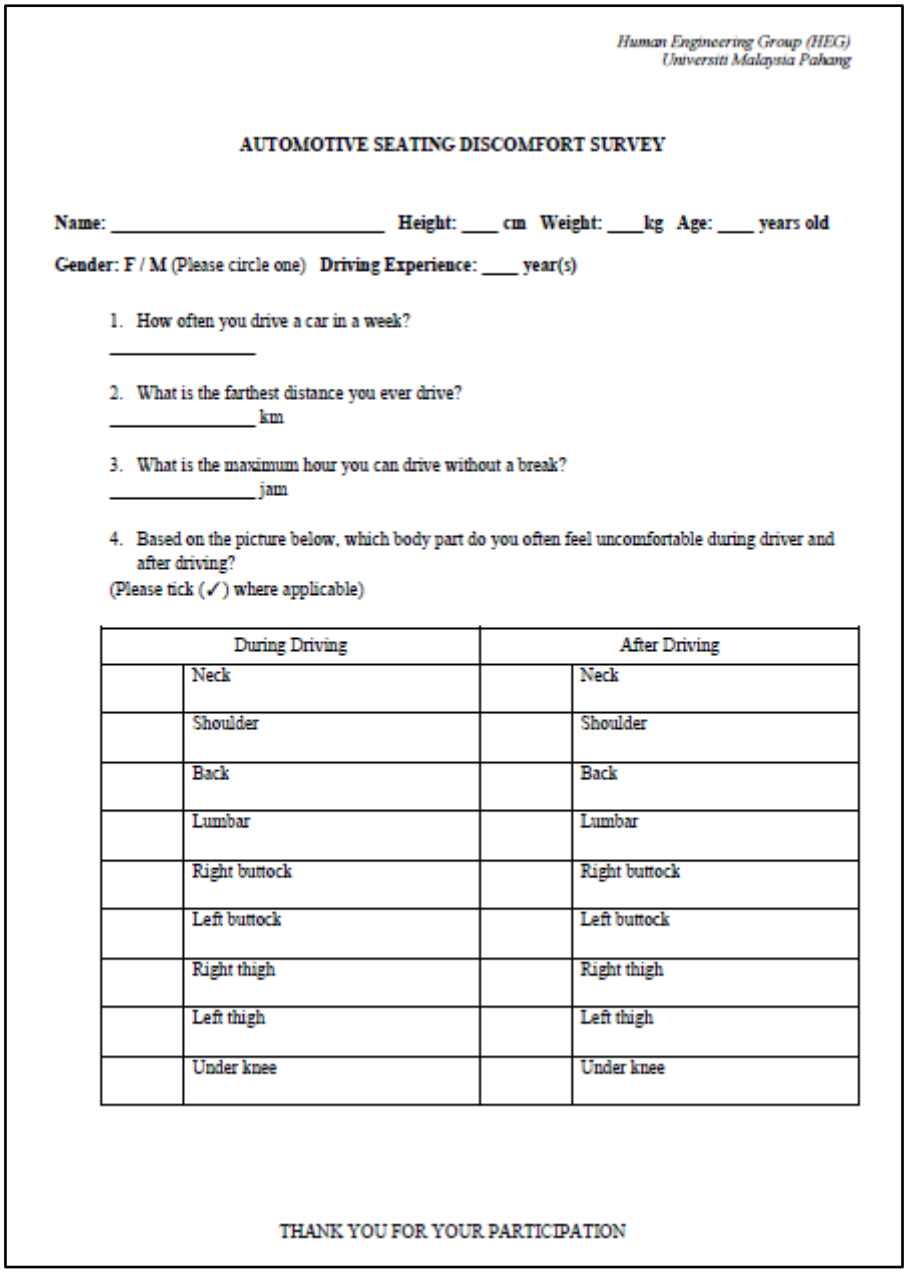
METHODS

The respondents were comprised of 30 subjects; students in University Malaysia Pahang (UMP) with a wide range of body size. The survey used random sampling method in which the subjects were directly approached to answer the questionnaires. The age of the respondents ranged from 20-27 years old with good health and body condition. The survey was conducted on subjects that have driving experience, valid driving license, and currently using a small size car in their daily life or having experience in driving small size car. The average speed the drivers drive was found to be 100km/h.

DEVELOPMENT OF QUESTIONNAIRE

The questionnaire was developed in Bahasa Malaysia on the basis of the requirements and practices in existing empirical studies. The questionnaire was developed based on the previous studies regarding comfort and discomfort of the body. It consists of (a) the general information of the drivers, and (b) the body part discomfort while and after driving.

In the general information section, the questionnaire was developed to collect the data of correlation between the distance of driving and the respondent's discomfort. In the body part section, the questionnaire was designed to gather the information of respondent's discomfort intensity. Additionally, it was developed on the basis of body parts interaction with the seat and led to an intense discomfort after a long hour drive. The body parts considered were the neck, shoulder, lumbar, buttock, thigh and under the knee. These parts were highlighted because they are the parts that interact the most with the seat. The questionnaires were distributed to the respondents in order to collect and analyze the discomfort. The questionnaire is shown in Figure 4.



Human Engineering Group (HEG)
Universiti Malaysia Pahang

AUTOMOTIVE SEATING DISCOMFORT SURVEY

Name: _____ **Height:** ____ **cm** **Weight:** ____**kg** **Age:** ____ **years old**

Gender: F / M (Please circle one) **Driving Experience:** ____ **year(s)**

1. How often you drive a car in a week?
_____

2. What is the farthest distance you ever drive?
_____ km

3. What is the maximum hour you can drive without a break?
_____ jam

4. Based on the picture below, which body part do you often feel uncomfortable during driver and after driving?
(Please tick (✓) where applicable)

During Driving		After Driving	
	Neck		Neck
	Shoulder		Shoulder
	Back		Back
	Lumbar		Lumbar
	Right buttock		Right buttock
	Left buttock		Left buttock
	Right thigh		Right thigh
	Left thigh		Left thigh
	Under knee		Under knee

THANK YOU FOR YOUR PARTICIPATION

Figure1- The sample of questionnaire

RESULTS

The results showed that the most drivers reported that their body usually experience discomfort while and after driving. The answers to the survey were based on the respondents' driving experiences and problems. Figure 5 shows the results of body discomfort while and after driving a mini size car.

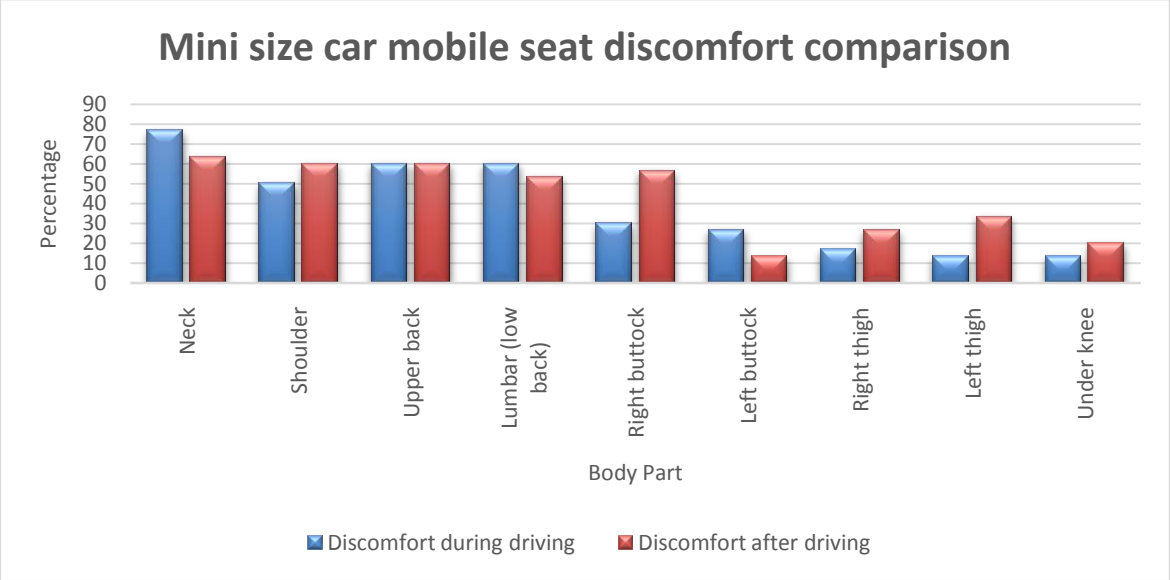


Figure2-Comparison of discomfort while and after driving a mini size car

The relation between the hours of driving and discomfort intensity is depicted in Table 1.

Table 1-Discomfort of body area due to driving hours

Driving Hour	Body area discomfort (%)								
	Neck	Shoulder	Upper back	Lower back (lumbar)	Right buttock	Left buttock	Right thigh	Left thigh	Under the knee
<1									
1-2	3.33	3.33			3.33	3.33	3.33	3.33	
2-3	3.33								
3-4	23.33	16.67	16.67	16.67	10.0	6.67	3.33		3.33
4-5	13.33	3.33	10.0	10.0			3.33	3.33	
>5	33.33	30.0	33.33	33.33	16.67	16.67	6.67	6.67	10.0

DISCUSSION

A long hour drive does not only cause the driver to feel tired but also causes the muscle to be fatigue and leads to discomfort[13,14]. Most of the drivers reported to feel discomfort at the neck while driving; followed by upper back and lumbar. From Figure 1, neck was reported as the body part that drivers felt discomfort the most while driving as compared to other parts such as lumbar and upper back. One possible explanation is the improper posture of seating while driving. Most of the driving time, the driver's head does not properly rested on the head rest. As a result, the neck becomes stiff and leads to discomfort.

Lumbar is one of the major parts that drivers felt discomfort when driving. The differences in positions, such as seat back angle, seat tilt and lumbar support position are the other relevant factors that support the discomfort of lumbar after a long hour drive. However, in the case of upper back, no significant difference of discomfort whileand after driving was found. (See Figure 5).

The survey also questioned the respondents about body area that they felt discomfort after driving. Majority said that they felt discomfort at the neck after driving; followed by their back and right buttock. The least discomfort part reported was under the knee for both while and after driving. One possible explanation is that the muscular muscle become tired and fatigue. Driving continuously contributes to muscle fatigue[15]. For a professional driver, the muscular fatigue might be severe.

The drivers reported to felt discomfort on the right shoulder, left buttock, right and left thigh and under the knee more after driving than while driving (see Figure 5). The possible explanation is that the driver focuses too much while driving. Thus, the driver only felt discomfort after

driving. The right buttock and thigh were found to produce more discomfort after driving than the left ones. The reason is that these body parts were aggressively used to control the speed actively in a long hour drive. Additionally, the driver tends to change their position a few times. Thus, it will make the driver feels awkward and not comfortable[16].

The respondents started to feel discomfort after 3 hours of driving (see Table 1). The discomfort was felt specifically at the neck, upper back, lumbar, and shoulder; followed by right and left buttock, thigh, and finally under the knee when the respondents drove for more than 5 hours. One possible explanation is that the muscle becomes fatigued due to the long journey and the activities of driving are constantly repeated. After a long time of discomfort, the muscles become fatigued and the driver starts to feel pain. This result showed a strong agreement with a study by Porter et al.[17], which showed significant differences when the respondents drive for a long hour. This can be interpreted that there is a significant difference in terms of muscle fatigue between long and short hour drive.

CONCLUSION

Comfort in automotive seating is important but it is subjective and difficult to measure, define, and interpret due to its psychophysical nature. There are many methods available to evaluate the comfort of automotive seating. A study usually focuses on the sitting posture analysis, pressure distribution, performance analysis and electromyography. This study used the survey method as the initial study of body area discomfort while and after driving. The findings showed that the discomfort was intense at the neck, upper back and lumbar while and after driving. However, the sample size was small, and limited to the age of 20 – 25 years. So, in the near future, the study should assess broader subjects and consider other factors such as age (i.e. range from 30s to 50s), anthropometry measures, internal vehicle packaging, driver's physic and physical, and also the environmental condition during the drive. Further survey on car seat comfort would be done to examine the correlation between the design of car seat and its comfort to the subjects.

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